Norwegian rock ptarmigan ectoparasites: chewing lice (Phthiraptera, Ischnocera) and feather mites (Astigmata, Psoroptidia)

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Feather mites (Astigmata, Psoroptidia), quill mites (Prostigmata, Syringophilidae) and chewing lice (Phthiraptera) are prominent parts of avian ectoparasites communities. Much attention has been directed to chewing lice but much less to mite infestations. The present study determined the prevalence and species of feather mites among Norwegian rock ptarmigan. Ten rock ptarmigan (*Lagopus muta* (Montin, 1781), six juveniles and four adults) collected in September 2012 at HOI, Odda: Møyfallsnuten, Norway (EIS 32, UTM 32V 6691051N 33427E), were examined for ectoparasites. Four species of ectoparasites were found, including two feather mites and two chewing lice. The feather mites *Tetraolichus lagopi* Mironov et al., 2010 and *Strelkoviacarus holoaspis* Mironov *et al.*, 2010, are species new to Norway. *T. lagopi* was highly prevalent (80%), with a mean intensity of 9.1 mites, while both prevalence (30%) and mean intensity (1.7 mites) were lower for *S. holoaspis*. Chewing lice *Goniodes lagopi* (Linnaeus, 1758) and *Lagopoecus affinis* (Children, 1836) are well known parasites of rock and willow ptarmigan (*Lagopus lagopus*) in Norway. Both *G. lagopi* (90%) and *L. affinis* (70%) were highly prevalent, with mean intensities of 7.9 and 4.6 lice, respectively. These rock ptarmigan ectoparasites are host-specific or parasitic to other closely related species (*Lagopus*, *Tetrao*, *Lyrurus*, and *Falcipennis*), and all have a very long history of association with their tetraonid (Tetraoninae) hosts reaching back to the North American heartland.

Key words: *Lagopus muta*, parasitism, host specific, coevolution, Norway.

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Introduction

The rock ptarmigan *Lagopus muta* (Montin, 1781) has a Holarctic breeding distribution and is found within arctic and alpine tundra regions (Montgomerie & Holder 2020). The ectoparasite fauna of the rock ptarmigan is composed of at least 10 species, of which seven can be considered host- or tetraonid (Tetraoninae)-specific (Skirnisson *et al.* 2012). The host-specific species include three chewing lice [two Ischnocera species, *Goniodes lagopi* (Linnaeus, 1758), *Lagopoecus affinis* (Children, 1836), and one Amblycera species, *Amyrsidea lagopi* (Grube, 1851)], three astigmatan species of feather mites (Psoroptidia, *Tetraolichus lagopi* Mironov *et al.*, 2010, *Strelkoviacarus holoaspis* Mironov *et al.*, 2010, and *Metamicrolichus islandicus* Mironov *et al.*, 2010), and one quill mite (Prostigmata, Syringophilidae, *Mironovia lagopus* Bochkov & Skirnisson, 2011). While ptarmigan researchers have paid attention to chewing lice, feather and quill mites have largely been ignored (see references in: Skirnisson *et al.* 2012, Skirnisson & Nielsen 2019).

The chewing lice *G. lagopi* and *L. affinis* are known ectoparasites of both rock and willow ptarmigan (*Lagopus lagopus* (Linnaeus, 1758)) in Norway (Mehl 1975), but no feather mites have been identified. The quill mite *M. lagopus*, originally described from rock ptarmigan in Iceland (Bochkov & Skirnisson 2011), has been recorded in Norway but on willow ptarmigan (*L. lagopus*) (Skoracki & Sikora 2011). The present study determined the prevalence and species of feather mites among Norwegian rock ptarmigan.

Methods

Ptarmigan samples. Ten rock ptarmigan, one adult and one juvenile male, three adult and two juvenile females, and three unsexed juveniles, were shot in September 2012 at HOI, Odda: Møyfallsnuten, Norway (EIS 32, UTM 32V 6691051N 33427E), and areas nearby. These game birds were collected during open season. The hunters skinned the birds at camp, and the skins with heads and wings attached were kept frozen at -20°C in individual packages until analysis in October 2018. The birds were sexed using both the loral stripe and size and colour of the combs (Montgomerie & Holder 2020) and aged based on pigmentation of the primaries (Weeden & Watson 1967). Two age classes were recognized: juveniles (hatched in 2012, about 3 months-old) and adults (hatched in 2011 or earlier, 15 months and older).

Collection and quantification of ectoparasites. A handheld vacuum cleaner (Princess turbo tiger, type 2755) was used to collect external parasites. The vacuum was modified for this purpose; the nozzle (4 × 1.5 cm) was connected to an external collection chamber fitted with a circular sack-like filter (92 cm^2; diameter of pores, 2–30 µm). Each skin was vacuumed systematically, being entirely vacuumed in 1–2 min. Thereafter, the filter was placed in a plastic bag and preserved in a freezer (-20°C) until analysis.

At the time of analysis, the content of the vacuum filter (feathers, skin particles, blood flakes, parasites, etc.) was poured into an open 400 mL glass jar. Approximately 100 mL of water was used to gently rinse the filter and collected in the glass jar. Seven drops of TRITON® X-100 were added to the water to reduce adhesive forces and promote settling of particles. Feathers were removed from the mixture and discarded after being rinsed further with water over the jar. After gently stirring, to remove air bubbles and particles from the surface, the contents were left to settle for several hours. Parasites were collected from the sediment at the bottom of the jar under a stereoscope at 10- to 35-fold magnification and preserved in ethanol.

The bare skin of each bird was visually inspected for signs of mange, an indicator of skin mite infestations (see Figure 4.2 in Stenkewitz 2017). Also, the rectrices were examined for feather holes, indicating the presence of the chewing louse *A. lagopi* (see Figure 2 in Stenkewitz *et al.* 2017). In addition, seven wing feathers per bird were examined for quill mites (Skirnisson & Nielsen 2019). The identification of chewing lice *G. lagopi* and *L. affinis* was based on Timmermann (1950). Mites were fixed in 70% ethanol and then mounted on microslides in Hoyer's medium (Gaud & Atyeo 1996). Identification of *T. lagopi* and *S. holoaspis* was based on Mironov *et al.* (2010).

Statistical analysis. Quantitative data, such as indices of abundance, existed for all the parasites observed. Descriptive statistics, including prevalence of infection, mean intensity of infection, and discrepancy index, were calculated for each parasite species. All calculations were done using Quantitative Parasitology 3.0 software

(Rozsa et al. 2000). Prevalence of infection is the percentage of hosts infected with the parasite, while mean intensity of infection is the mean number of parasites per host based on infected individuals only. The discrepancy index ranges between 0 and 1; high values indicate aggregated distribution and low values a uniform distribution. The Sterne method was used to calculate the 95% confidence limits for prevalence, and the bootstrap method was used to calculate 95% confidence limits for mean intensity and the discrepancy index.

Results

Two species of feather mites were recorded, *T. lagopi* and *S. holoaspis* (Figure 1, Table 1). Prevalence was 80% for *T. lagopi* and 30% for *S. holoaspis*, and mean intensities were 9.1 and 1.7 mites, respectively. Both species showed a clumped distribution within the host population (dispersion index, 0.646 and 0.709, respectively). No sign of skin or quill mites were found. Two species of chewing lice were found, *G. lagopi* and *L. affinis* (Figure 2, Table 1). Both were highly prevalent, with *G. lagopi* found on 90% of hosts and *L. affinis* on 70%. Mean intensities were 7.9 and 4.6 lice, respectively. *L. affinis* showed a clumped distribution (dispersion index, 0.614) but *G. lagopi* much less so (dispersion index, 0.350). No *A. lagopi* were found nor holes in tail feathers.

Discussions

We have studied ectoparasites of Norwegian rock ptarmigan and found two species of chewing lice and two species of feather mites. Both feather mites are new for the Norwegian fauna, but the chewing lice are well known ptarmigan parasites in Norway (Mehl 1975). The present observational study of ectoparasite prevalence on Norwegian rock ptarmigan is not comprehensive as the sample size

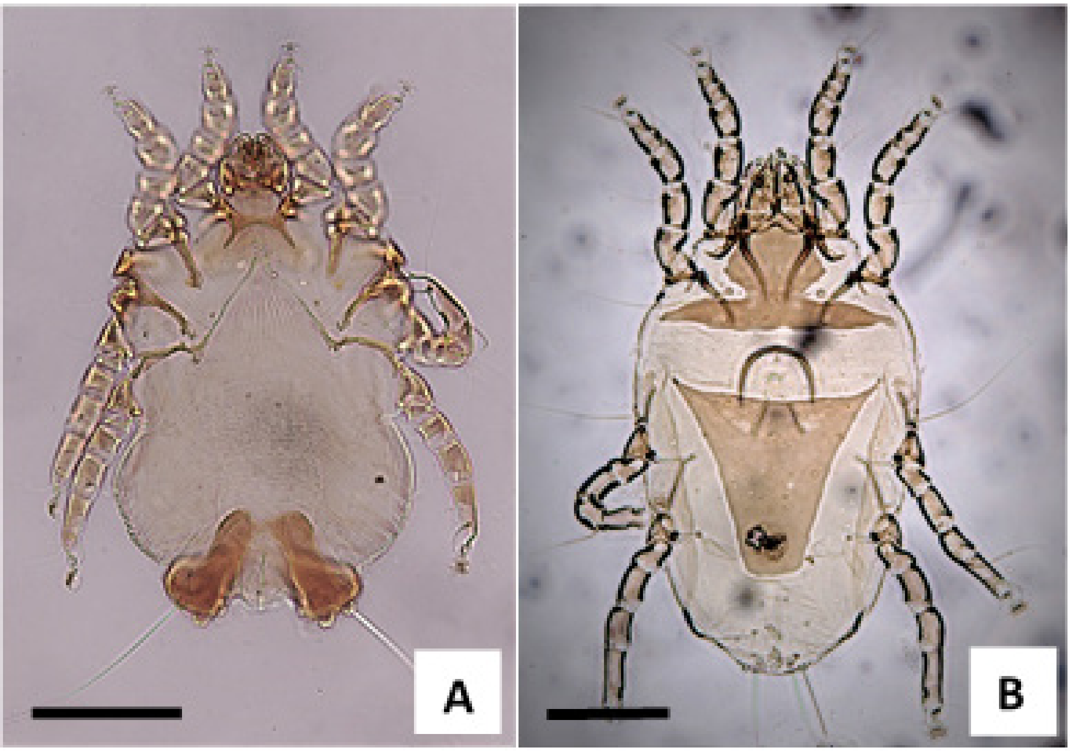

FIGURE 1. Astigmatan feather mites detected in the plumage of rock ptarmigan *Lagopus muta* from Norway. **A**. *Strelcoviacarus holoaspis*, male. **B**. *Tetreaolichus lagopi*, female. Scale bar 200 µm.

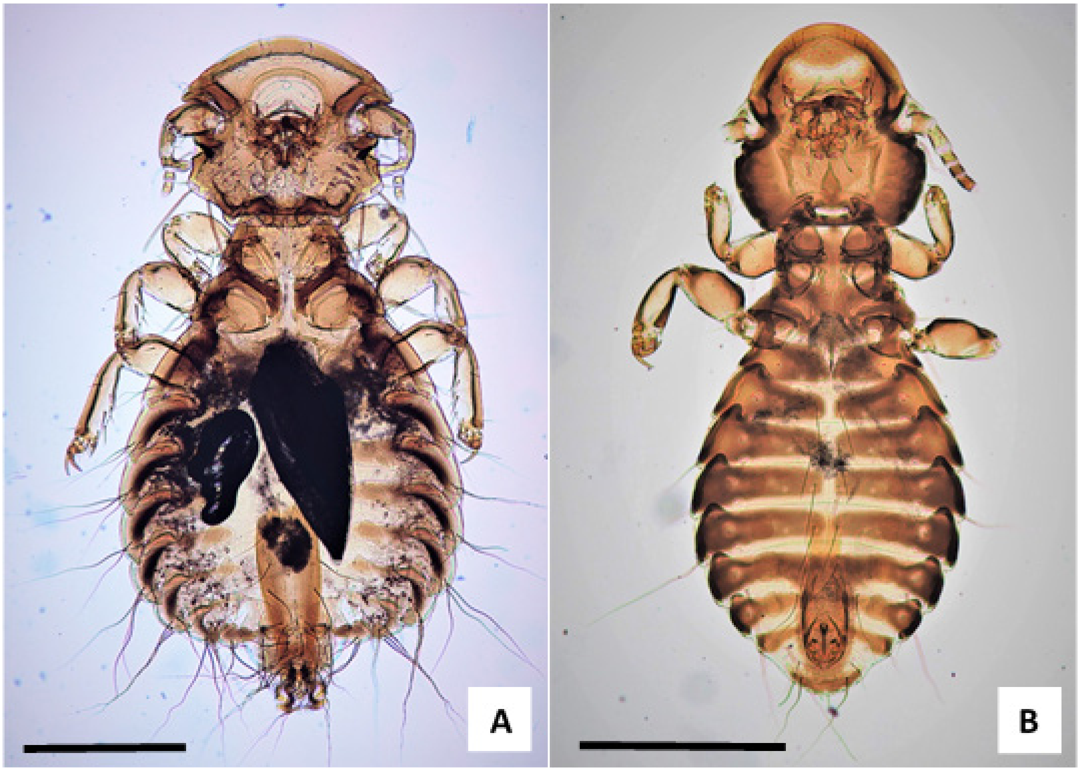

FIGURE 2. Ischnocerid chewing lice detected in the plumage of rock ptarmigan *Lagopus muta* from Norway. **A**. *Goniodes lagopi*, male. **B**. *Lagopoecus affinis*, male, missing are segments of legs and left antenna. Scale bar 500 µm.

was small (10 birds). Further, the sampled birds were most likely allowed to touch dead ptarmigan during the hunt. Though these limitations should be considered when interpreting the data, they do not negate the presence of the identified feather mites among rock ptarmigan in Norway.

In general chewing lice and many species of feather mites parasitizing birds are host-specific or confined to a coterie of related host species (Dabert & Mironov 1999, Price *et al.* 2003). These parasites have a long history of coevolution with their respective hosts. Ptarmigan (*Lagopus*) evolved in North America, where three species occurred: rock, willow, and white-tailed ptarmigan (*Lagopus leucura*). Rock and willow ptarmigan have a Holarctic distribution, but the white-tailed ptarmigan is confined to the Nearctic. The ancestral *Lagopus* diverged from other tetraonids ancestral to *Tetrao, Lyrurus*, and *Falcipennis* approximately 7–10 million years ago (MYA). The white-tailed ptarmigan diverged from the *Lagopus* lineage about 5 MYA, and the lineage ancestral to willow and rock ptarmigan diverged 2–3 MYA or at the start of the Pleistocene Epoch (Persons *et al.* 2016). Both rock and willow ptarmigan dispersed to the Palearctic region. Their current Holarctic distribution reflects a complicated story of restricted refugium during glacial periods, with spread during interglacial periods (Holder *et al.* 1999, 2000, Lucchini *et al.* 2001). The rock ptarmigan is divided into 20+ subspecies, and these races are often divided into two main groups (*rupestris* and *muta*) based on the colour of summer and autumn plumages (Vaurie 1965). The *muta* group is confined to Fennoscandia, Scotland, the Alps, and the Pyrenees; all other populations belong to the *rupestris* group. There is a 600-km gap in the breeding distribution of the rock ptarmigan between the easternmost *muta* population on the Kola Peninsula and the westernmost *rupestris* population on the coast north of the Ural Mountains (Montgomerie &

TABLE 1. Ectoparasites from rock ptarmigan *Lagopus muta muta* in Norway: species, host age (ad = adult, juv = juvenile bird), sample size (n), prevalence, 95% confidence limits (95% cl), number of infected hosts, mean intensity, and discrepancy index.

Species	Host age	n	Prevalence (%)	95% cl	No. infected hosts	Mean intensity	95% cl	D	95% cl
Tetraolichus lagopi	All	10	80	45-96	8	9.1	3.0-26.2	0.646	0.528-0.780
	Juv	6	100	59-100	6	11.7	3.7-32.4	0.506	0.401-0.627
	Ad	4	50	10-90	2	1.5	-	0.467	-
Strelkoviacarus holoaspis	All	10	30	9-62	3	1.7	1.0-2.3	0.709	0.455-0.818
	Juv	6	50	15-85	3	1.7	1.0-2.3	0.543	0.286-0.714
	Ad	4	0	-	0	-	-	-	-
Goniodes lagopi	All	10	90	55-100	9	7.9	4.7-10.6	0.350	0.180-0.594
	Juv	6	83	41-99	5	10.4	8.8-11.8	0.209	0.058-0.714
	Ad	4	100	47-100	4	4.8	1-10	0.411	0.212-0.450
Lagopoecus affinis	All	10	70	38-91	7	4.6	1.4-8.7	0.614	0.496-0.802
	Juv	6	67	27-94	4	7.3	1.8-12.0	0.507	0.302-0.714
	Ad	4	75	25-99	3	1.0	-	0.200	-

Holder 2020). The parasite-host interaction between feather mites and chewing lice on one hand and the rock ptarmigan on the other are suspected to trace their origin to the North American heartland. This long history of association has been characterized by parasites switching between sympatric grouse species (Sweet *et al.* 2020)

The two species of chewing lice found parasitizing the rock ptarmigan in the present study were all confined to hosts within the *Lagopus-Tetrao-Lyrurus-Falcipennis* clade (Table 2). The chewing louse *A. lagopi* has not been confirmed for rock ptarmigan belonging to the *muta* group but exists in the western Palearctic and has been recorded for capercaillie *Tetrao urogallus* in Sweden (Scharf & Price 1983). *A. lagopi* was the least prevalent (17%) of the three chewing lice parasitizing rock ptarmigan in Iceland, while the prevalence of *G. lagopi* and *L. affinis* was 75% and 56%, respectively (Nielsen *et al.* 2020). Prevalence values in the current study for *G. lagopi* (90%) and *L. affinis* (70%) were both higher than that observed for rock ptarmigan in Iceland, but in line with what has been observed for willow ptarmigan in Norway (97% and 93%, respectively, Holmstad *et al.* 2008).

Studies that have systematically screened for feather and quill mites parasitizing rock ptarmigan have only been done in Iceland (Skirnisson et al. 2012), wherein four species of astigmatan feather mites were found. One, *T. lagopi*, is host- or genus-specific, and the genus *Tetraolichus* is restricted to tetraonid hosts (Atyeo & Gaud 1992). These mites have a direct life cycle and disperse through contact between mother-offspring (vertical transmission) or interacting adults (horizontal transmission). Apart from Iceland and Norway, *T. lagopi* has been found in rock ptarmigan in Greenland (unpublished data) and willow ptarmigan in Russia and Kazakhstan (Mironov *et*

TABLE 2. Known host species of three chewing lice parasitizing rock ptarmigan within its geographic range.

Chewing louse	**Known hosts***
Goniodes lagopi	Rock ptarmigan *Lagopus muta*, willow ptarmigan *Lagopus lagopus*, white-tailed ptarmigan *Lagopus leucura*
Lagopoecus affinis	Rock ptarmigan, willow ptarmigan, capercaillie *Tetrao urogallus*
Amyrsidea lagopi	Rock ptarmigan, willow ptarmigan, siberian grouse *Falcipennis falcipennis*, capercaillie, black grouse *Lyrurus tetrix*

**Pryce et al. 2003, Smith et al. n.d.*

al. 2010). Two other astigmatan feather mite species observed in Iceland, *S. holoaspis* and *M. islandicus*, are also considered to be host-specific as they were not observed to use louse flies (Diptera: Hippoboscidae) for dispersal (Guðmundsson *et al.* in press). Also, both species have been registered for rock ptarmigan in Greenland (KS & ÓKN unpublished data), where louse flies do not occur (Böcher *et al.* 2015). In the present study, *S. holoaspis* was recorded on rock ptarmigan in Norway but not the mite *M. islandicus*. However, it should be noted that some species within both the genera *Strelkoviacarus* and *Metamicrolichus* are known to use louse flies for dispersal (Mironov *et al.* 2010). The fourth astigmatan feather mite observed in Iceland is *Myialges borealis* Mironov *et al.*, 2010. Like other *Myialges* species, is believed to live on or in the skin of its avian host and most likely non-host-specific (prevalence of infection for rock ptarmigan in Iceland is 16%, exclusively adult females have been detected, Nielsen *et al.* 2020, Skirnisson *et al.* 2012). It has a complicated life cycle, and gravid females are hyperparasites on louse flies, laying their eggs on the flies and using them as a means for dispersal (Mironov et al. 2010). In Iceland, the louse fly *Ornithomyia chloropus* Bergot, 1901, parasitizes the rock ptarmigan along with a wide array of upland birds, including Passeriformes, Charadriiformes, Strigiformes, and Falconiformes. *M. borealis* hyperparasites can be quite prevalent on *O. chloropus* in late summer and autumn in Iceland (prevalence 14–91%, Guðmundsson *et al.* in press). In Norway, *O. chloropus* is a common parasite of ptarmigan (Mehl 1975) but the flie's association with *Myalges* mites has not been reported on.

The prostigmatan ptarmigan quill mite *M. lagopus* is host-specific but occurs at low prevalence among Icelandic rock ptarmigan (7%, Skirnisson & Nielsen 2019). Low prevalence could be the reason it was not found in the current sample as this species is known to parasitize willow ptarmigan in Norway (Skoracki & Sikora 2011). Prevalence values for *T. lagopi* and *S. holoaspis* in the present study were similar to that observed in Iceland, but mean intensity values were lower (Nielsen *et al.* 2020). For *T. lagopi*, prevalence and mean intensity values for Norway and Iceland were 80% and 9.1 mites versus 92% and 26.3 mites, respectively; values for *S. holoaspis* were 30% and 1.7 mites versus 44% and 38.1 mites, respectively.

In conclusion, four ectoparasite species were found in the present sample of rock ptarmigan in Norway, including two species of chewing lice (*G. lagopi* and *L. affinis*) and two species of feather mites (*T. lagopi* and *S. holoaspis*). All four species can be considered as host- or tetraonid-specific parasites. On the other hand, three other host-specific rock ptarmigan parasites known from other parts of its geographic range were not found, including the chewing louse *A. lagopi*, quill mite *M. lagopus*, and feather mite *M. islandicus*. Furthermore, two species of known non-host-specific parasites of Norwegian rock ptarmigan, *O. chloropus* and the flea (Siphonaptera) *Ceratophyllus garei* Rothschild, 1902, (Mehl 1975) were not found. Nonetheless, *A. lagopi* and *M. lagopus* are still suspected to be among rock ptarmigan parasites present in Norway. To confidently describe the ectoparasite fauna of the rock ptarmigan in Norway a larger host sample is needed, minimum 20–30 hosts (Jovani & Tella 2006).

References

Atyeo, W.T. & Gaud, J. 1992. The identity of *Pterolichus obtusus* Robin, 1877 with descriptions of new genera and species of feather mites (Acarina, Pterolichidae) from the Galliformes (Aves) *Acarologia* 33, 193–206.

Bochkov, A.V. & Skirnisson, K. 2011. Description of the life stages of quill mite *Mironovia lagopus* sp. nov. (Acari: Syringophilidae) parasitizing the rock ptarmigan *Lagopus muta* (Phasianidae) from Iceland. *Parasitology Research* 108, 715–722.

Böcher, J., Kristensen, N.P., Pape, T. & Vilhelmsen, L. (Eds.) 2015. *The Greenland entomofauna: an identification manual of insects, spiders and their allies*. 881 pp. Brill, Amsterdam.

Dabert, J. & Mironov, S.V. 1999. Origin and evolution of feather mites (Astigmata). *Experimental & Applied Acarology* 23, 437–454.

Gaud, J. & Atyeo W.T. 1996. Feather mites of the world (Acarina, Astigmata): The supraspecific taxa. *Ann. Mus. r. Afr. cent., Sci. Zool.* 277, Part I (text), 1−193, Part II (Figures), 191−436.

Guðmundsson, S.Ö., Skírnisson K. & Nielsen Ó.K. in press. The hippoboschid *Ornithomya chloropus* in Iceland: life cycle, hosts and phoresy. In Icelandic *Náttúrufræðingurinn*.

Holder, K., Montgomerie, R. & Friesen, V.L. 1999. A test of the glacial refugium hypothesis using patterns of mitochondrial and nuclear DNA sequence variation in rock ptarmigan (*Lagopus mutus*). *Evolution* 53, 1936–1950.

Holder, K., Montgomerie, R. & Friesen, V.L. 2000. Glacial vicariance and historical biogeography of rock ptarmigan (*Lagopus mutus*) in the Bering region. *Molecular Ecology* 9, 1265–1278.

Holmstad, P.R., Jensen, K.H. & Skorping, A. 2008. Ectoparasite intensities are correlated with endoparasite infection loads in willow ptarmigan. *Oikos* 117, 515–520.

Jovani, R. & Tella, J.L. 2006. Parasite prevalence and sample size: misconceptions and solutions. *Trends in Parasitology* 22, 214–218.

Lucchini, V., Hoglund, J., Klaus, S., Swenson, J. & Randi, E. 2001. Historical biogeography and a mitochondrial DNA phylogeny of grouse and ptarmigan. *Mol Phylogenet Evol* 20, 149–162.

Mehl, R. 1975. Rypenes ektoparasitter i Norge. *Fauna* 28, 208–215.

Mironov, S.V., Skirnisson, K., Thorarinsdottir, S.T. & Nielsen, O.K. 2010. Feather mites (Astigmata: Psoroptidia) parasitising the rock ptarmigan *Lagopus muta* (Montin) (Aves: Galliformes) in Iceland. *Systematic Parasitology* 75, 187–206.

Montgomerie, R.D. & Holder, K. 2020. Rock Ptarmigan (*Lagopus muta*), version 1.0. Birds of the World. Billerman, S. M., Keeney, B. K., Rodewald, P. G. & Schulenberg, T. S. (Eds.). Cornell Lab of Ornithology, Ithaca, New York. https://doi.org/10.2173/bow.rocpta1.01

Nielsen, Ó.K., Morrill, A., Skírnisson, K., Stenkewitz, U., Pálsdóttir, G.R. & Forbes, M.R. 2020. Host sex and age typically explain variation in parasitism of rock ptarmigan: implications for identifying determinants of exposure and susceptibility. *Journal of Avian Biology* 51, https://doi.org/10.1111/jav.02472

Persons, N.W., Hosner, P.A., Meiklejohn, K.A., Braun, E.L. & Kimball, R.T. 2016. Sorting out relationships among the grouse and ptarmigan using intron, mitochondrial, and ultra-conserved element sequences. *Molecular Phylogenetics and Evolution* 98, 123−132.

Price, R. D., Hellenthal, R. A., Palma, R. L., Johnson, K. P. & Clayton, D. H. 2003. *The chewing lice: World checklist and biological overview*. 501 pp. Illinois Natural History Survey Special Publication, Champaign, Illinois.

Rozsa, L., Reiczigel, J. & Majoros, G. 2000. Quantifying parasites in samples of hosts. *Journal of Parasitology* 86, 228–232.

Scharf, W.C. & Price, R.D. 1983. Review of the *Amyrsidea* in the subgenus *Argimenopon* (Mallophaga: Menoponidae). *Annales Entomolocical Society of America* 76, 441–451.

Skirnisson, K. & Nielsen, O.K. 2019. Quill mite infestation of rock ptarmigan *Lagopus muta* (Aves: Phasianidae) in relation to year and host age, sex, body condition, and density. *Parasitology Research* 118, 2643–2650.

Skirnisson, K., Thorarinsdottir, S.T. & Nielsen O.K. 2012. The parasite fauna of rock ptarmigan (*Lagopus muta*) in Iceland: Prevalence, intensity, and distribution within the host population. *Comparative Parasitology* 79, 44−55.

Skoracki, M. & Sikora, B. 2011. Quill mites (Acari: Syringophilidae) associated with galliform birds (Aves: Galliformes). *Zootaxa* 2966, 13–30.

Smith, V.S., Broom, Y. & Dalgleish R., n.d. Phthiraptera.info (web resource). Available from:

http://phthiraptera.info/ (17 January, 2021).

Stenkewitz, U. 2017. *Parasites and population change of rock ptarmigan in Iceland.* Ph.D. thesis. 170 pp. University of Iceland, Reykjavik, Iceland.

Stenkewitz, U., Nielsen, Ó.K., Skírnisson, K. & Stefánsson, G. 2017. Feather holes of rock ptarmigan are associated with amblyceran chewing lice. *Wildlife Biology*, wlb.00255.

Sweet, A.D., Wilson, R.E., Sonsthagen, S.A. & Johnson, K.P. 2020. Lousy grouse: Comparing evolutionary patterns in Alaska galliform lice to understand host evolution and host-parasite interactions. *Ecology and Evolution* 10, 8379–8393.

Timmermann, V.G. 1950. Beiträge zur Kentniss der Ektoparsitenfauna Isländischer Säugetiere und Vögel, 3. Mitteilung. *Fauna Islandica, Miscellaneous papers on Icelandic Zoology* 1, 1-8.

Vaurie, C. 1965. *The birds of the Palearctic fauna*. 763 pp. H.F. & G. Witherby, London.

Weeden, R.B. & Watson, A. 1967. Determining the age of rock ptarmigan in Alaska and Scotland. *Journal of Wildlife Management* 31, 825–826.

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